THE IMPACT OF GREEN CANE PRODUCTION SYSTEMS ON MANUAL AND MECHANICAL FARMING OPERATIONS

By

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Abstract

MANY sugar industries around the globe have moved, or are in the process of moving, to green cane production systems. Some of these industries have done so because of pressure from local communities or because of government legislation regarding environmental pollution, while others have done so for a variety of agronomic and economic reasons. Nevertheless, it is estimated that at present more than 50% of all sugarcane around the world is still burnt prior to harvesting. Burning the cane is seen as an effective way of maintaining high manual cutter and mechanical harvester outputs and to deliver cleaner cane to the mills. However, there are many disadvantages associated with burning, which include atmospheric pollution, and soil and water losses. Cut to crush delays in burnt cane have been recognised as one of the main causes of increased dextran levels in sugar. Many factors need to be considered when moving to a green cane production system, with the main issues involving the changes required to adapt to different agronomic, mechanical and labour regimes. Factory performance and social and economic implications also need to be taken into account. This paper highlights many of the issues that affect the operational, economic and social considerations that need to be evaluated when changing from a burnt to green cane harvesting system. These issues include manual and mechanical harvesting efficiencies and performances, handling of sugarcane residues and machinery availability and suitability. Other areas such as cane quality, and loading and transport of sugarcane are also discussed.

Introduction

The burning of sugarcane prior to harvesting has been the accepted practice in many of the world’s sugar producing industries for many decades. Burning not only removes most of the unwanted vegetative material, but also allows for improved manual cutter performance, chopper harvester pour rates, mechanical loading rates and vehicle payloads.

Many sugarcane industries are under increasing public and environmental pressures to reduce or eliminate the practice of burning cane prior to harvesting. In several countries, including Brazil and Colombia, legislation has been passed to limit and/or prohibit the burning of sugarcane. Aside from environmental and public pressures there are numerous advantages to green cane harvesting.

Cane quality is improved by slower cane deterioration rates when harvested unburned (Wood, 1976) and reduced harvest-to-crush delays. Agronomic advantages of green cane harvesting can include improved water infiltration rates, reduced water and soil run-off, and better weed control, some or all of
which can result in improved yields (Thompson and Dick, 1990). Tops and trash can be regarded as assets rather than ‘extraneous matter’ and have a host of alternative uses.

While it is estimated that 80% of the world’s sugarcane is still being harvested manually, there are industries such as Australia and Florida, Louisiana and Texas in the United States of America, as well as smaller producers such as Papua New Guinea, where the entire sugarcane crop is harvested mechanically.

In Argentina, Brazil, Colombia, Guatemala, Indonesia and the Sudan, the proportion of sugarcane that is harvested mechanically is steadily increasing. There are many reasons why sugar producing countries have moved to mechanical harvesting systems.

These include a shortage of or unwillingness by labour to harvest the cane, high labour costs and/or poor labour performance.

The major implications of moving from a burnt to a green cane harvesting regime using either manual or mechanical harvesting systems, as well as factors impacting on socio-industrial aspects within an industry, are now discussed.

**Harvesting systems**

At present there are only two harvesting systems that can be used successfully to harvest green cane. These are manual harvest of whole stalks (accompanied by manual or mechanical loading) and the fully mechanised chopper harvesting system. A particular industry may be facing any one or all of the following choices:

- Changing from manual burnt cane to manual green cane.
- Changing from manual burnt cane to chopper harvested green cane.
- Changing from chopper harvested burnt cane to chopper harvested green cane.

The implications of changing to a green cane harvesting regime using the above alternative harvesting methods are now discussed.

**Manual burnt cane to manual green cane harvesting**

Well supervised manual harvesting and loading in burnt cane usually results in the cleanest cane for milling. Few industries would voluntarily change from burnt cane manually cut to green cane manually cut unless significant environmental or sustainability issues made the change necessary for the survival of the industry.

It is widely accepted that manual harvesting rates are considerably lower in green cane than in burnt cane. This not only results in increased harvesting, loading and transport costs, but increased labour-associated costs such as accommodation, and medical and pension benefits.

In South Africa, a survey revealed that manual harvesting rates were reduced by 28% when cutting and stacking, and 15% when cutting and bundling green cane when compared with rates for burnt cane (Meyer and Fenwick, 2003).

To mitigate the cost of hand stripping cane during the harvesting operation, new varieties which ‘self trash’ at maturity have been developed and have been very successful. In the Philippines, over 50% adoption by the industry of these varieties has occurred quite rapidly (pers. commun.¹).

The primary advantage of these varieties is the more rapid harvesting rate, as the cutter has very limited stripping to do if the cane is fully mature. In traditional varieties, cutter productivity in green cane is substantially reduced relative to burnt cane. Self-trashing varieties allow cutters to approach burnt cane cutting rates in moderately sized erect crops.

Mechanical loading rates and vehicle payloads in untrashed or partially trashed green cane are also lower than in burnt cane (de Beer et al., 1989).

**Manual burnt to chopper harvested green cane**

In changing to green cane harvesting, the anticipated reduction in manual cutter productivity and subsequent increase in harvesting costs has been the catalyst for the introduction of machine harvesting, typically chopper harvesting. At present, chopper harvesting is the only system that can harvest and clean erect or lodged, burnt or green cane.

¹ Leon M. Arceo, Director Philippine Sugar Research Institute Foundation Inc (Philsurin), Rm1405, Security Bank Centre, 6776 Ayala Ave Makate City Philippines (personal communication with C. Norris, February 2003).
The move from manual harvesting of burnt cane to machine harvested green cane is a dramatic organisational change that necessitates stringent field preparation, a host of agronomic considerations, and a completely different cane transport system.

The more mechanised the harvesting operation becomes, the greater the risk of increased cane losses, stool damage and soil compaction. Cane losses will be greater in mechanically harvested green cane than in manually harvested burnt cane.

There are numerous factors to be considered when implementing a fully mechanised chopper harvesting system (Ridge et al., 1996; Meyer, 1999). In terms of field preparation and layout, the following need to be addressed:

- Adequate headlands.
- Sufficiently flat and rock-free fields for safe operation of harvesters and haulout equipment.
- Compatible cultural operations, including straightness of rows (the row profile to allow the harvester to minimise pickup losses) and appropriate chamfering on cross-drains. Typically, mechanisation of cultural practices such as hilling is a prerequisite to achieve suitable row shapes.
- Adequate row lengths, number of haulout units, haulout capacity for efficient and cost effective harvester operation (Brennan et al., 1996; Ridge and Dick, 1985; Salassi and Champagne, 1996).
- Compatible row spacing of the cane and machinery. With single row chopper harvesting, both the harvester wheels and the haulout wheels traverse each interrow twice.

While most mechanised cane production has been undertaken on 1.5 m crop row spacing, this row spacing is not compatible with the majority of single row mechanical harvesters, which are manufactured with 1.8–2.0 m wheel/track spacing. With burnt cane practices, compaction alleviation and profile remediation after mechanical harvesting can be easily conducted; however, under green cane harvesting regimes, these operations are more difficult to achieve (Vaux et al., 2004). The adoption of crop spacing compatible with the harvesters and transport equipment should be undertaken as part of the move to mechanised harvesting.

**Burnt to green chopper harvesting**

Despite very significant advances by harvester manufacturers, harvester performance in green cane is reduced, repair and maintenance costs increase, and fuel consumption is higher. The impact of changing from burning to harvesting green cane creates a number of challenges in the operation and performance of a chopper type harvester. These changes can be addressed in the way they flow through the machine.

**Visibility**

In predominantly erect crops, the adverse impact of harvesting green cane is limited; however, the trash blanket left on the soil surface prevents the operator from being able to see the quality of ‘ground job’ being done by the machine. In the move from burnt to green cane chopper harvesting, operator training is seen as a major issue, especially in difficult conditions with respect to visibility.

Recent research has indicated that GPS-based guidance systems dramatically reduce the operator workload when operating in recumbent unburnt cane, provided the field was planted using a similar guidance system.

**Gathering and feeding**

When operating in light and erect crops, modern chopper harvesters have few problems with the gathering and feeding of cane stalks into the harvester (Norris et al., 1998). As crop conditions become more sprawled and lodged, the harvester must align and straighten the cane along the direction of the row for it to feed into the throat of the machine.

Not only is there significantly more biomass being manipulated, but the friction between cane stalks, and between cane stalks and trash, is significantly higher under unburnt conditions than when operating in burnt cane (Schembri and Garson, 1996). When operating in recumbent crops, efficient gathering and feeding of the crop is therefore increasingly difficult to achieve, and feed through the machine becomes more erratic (Davis and Norris, 2002). Higher levels of operator skill are then required to maintain machine productivity.
Developments in harvester design have been demonstrated to enhance the performance of machines under recumbent crop conditions; however, machine performance and damage to the stool remain significant issues. These effects are most pronounced in high yielding irrigated crops or ‘two-year’ crops.

**Billeting losses**

Billeting losses in chopper harvesters are inversely related to billet length. However, they are also directly related to instantaneous material flow rates through the machine, chopper/feedtrain tip speed relationship and the characteristics of the cane (Hockings et al., 2000).

At moderate harvesting rates, where a uniform cane feed to the choppers can be maintained, there is little practical difference in the billeting losses between burnt and green cane. However, as crop yield increases and feed becomes less uniform, losses in green cane will be higher (Davis and Norris, 2002).

**Extraneous matter—trash and leaf**

The efficiency of chopper harvesters in removing trash is dependent on cane variety, crop condition, crop yield, harvester pour rates and harvesting conditions (Whiteing et al., 2001) and, under given field conditions, final extraneous matter (EM) levels will be closely related to initial trash levels (Ridge and Dick, 1987).

Recumbent crops result in higher EM levels and cane loss than erect crops of similar yield and variety (Whiteing et al., 2001) because of the less uniform feed of these crops through the machine.

Typically, the harvester extraction system removes 50–80% of the pre-harvest trash and leaf, depending on harvesting conditions (pers. commun.²), and extractor fan speed has a relatively limited impact on final EM levels, within the typical operating range.

**Extraneous matter—soil and root material**

Under green cane harvesting conditions, soil in cane levels will typically be similar to burnt cane harvesting; however, a much greater proportion of the soil will be attached to the trash rather than the cane stalk (Henkel et al., 1979). Roots and stools can also contribute a significant proportion of the soil loading in all machine harvested cane.

Research in Brazil has shown that equipping chopper harvesters with floating base cutters not only reduced cane losses, but also reduced soil levels and stool levels in the cane delivered to the factory (Neves et al., 2001).

**Cleaning losses**

Cleaning losses when harvesting unburnt crops are typically the largest single source of loss with chopper harvesting. However, losses can also be high in burnt crops if extractor fan speed is excessive. Higher fan speeds reduce extraneous matter, but also result in higher cane losses (de Beer et al., 1996; Whiteing et al., 2004).

Generally, cane loss will be low at fan speeds giving blade tip speeds below 70 m/sec; however, levels of EM removal may not be considered adequate.

Increasing fan tip speeds increases total extraction, but reduces selectivity of trash removal, and tip speeds above 85 m/sec should be avoided as cane loss will be very high (pers. commun.²).

**Operating costs**

Harvesting of unburnt cane results in greater loadings on a number of machine functions, which therefore results in both higher operating costs and maintenance costs. The most significant areas of difference are in maximum machine productivity and increased fuel consumption per tonne harvested.

Ridge et al. (1996) undertook a detailed study of machine productivity in burnt and green cane (Figure 1).

In lighter crops, they found that the difference between burnt and green cane productivity was less than in larger crops, with the ground speed limitations of tracked machines introducing an artificial limit in very light crops.

While these data indicate typical machine performance under Australian conditions, ‘Best Practice’ harvesting strategies where low cane loss and low EM levels are targeted require further reductions in pour rate.

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Typical differences in harvesting rates and fuel consumption between green and burnt cane achieved in Mauritius are shown in Table 1 (MSIRI/CIRAD, 1993) and Table 2 (pers. commun.) respectively. Differences in maintenance costs relate primarily to reduced chopper blade life and a more significant reduction in extractor fan blade life.

<table>
<thead>
<tr>
<th>Year</th>
<th>Harvester output (t/h)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green cane</td>
<td>Burnt cane</td>
</tr>
<tr>
<td>1991</td>
<td>25.47</td>
<td>35.27</td>
</tr>
<tr>
<td>1992</td>
<td>30.90</td>
<td>40.57</td>
</tr>
<tr>
<td>1993</td>
<td>31.21</td>
<td>40.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Green cane</th>
<th>Burnt cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonnes cane harvested</td>
<td>269 887</td>
<td>70 375</td>
</tr>
<tr>
<td>Fuel used (litres)</td>
<td>319 107</td>
<td>72 996</td>
</tr>
<tr>
<td>Fuel consumption (L/tonne)</td>
<td>1.18</td>
<td>1.04</td>
</tr>
</tbody>
</table>

Research in Argentina (Meyer et al., 2005) indicated that losses in total recoverable sucrose were similar with green cane harvesting and with burnt cane harvesting, with the greatest losses associated with the trash removal function in unburnt cane and deterioration under burnt cane harvesting conditions. These research results are consistent with results from many other countries.

**Sugarcane transport**

A move from burnt to green cane manual harvesting will have little impact on transport systems if the cane is hand stripped as part of the harvesting process, and if appropriate protocols are in place to ensure low trash levels in the delivered cane. Research carried out in South Africa based on different manual harvesting systems showed that varying amounts of trash and tops in the cane sample can have a severe negative impact on vehicle payloads (de Beer et al., 1989).
If the move to green cane harvesting is associated with the collection of cane residues for industrial use, the impact on load density is very significant (Meyer et al., 2005).

The move from burnt to green cane chopper harvesting will typically result in only a small increase in total EM, but the changes in the characteristics of the EM are significant, with higher proportions of low density material in unburnt cane. Typical differences between whole and billeted cane load densities are given in Table 3 (Anon., 2004).

**Table 3—Typical differences in whole stalk and billeted cane load densities.**

<table>
<thead>
<tr>
<th>Cane</th>
<th>lb/ft³</th>
<th>kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole stick cane, tangled and tamped down as in a cane transport vehicle</td>
<td>12.5</td>
<td>200.2</td>
</tr>
<tr>
<td>Whole stick cane, neatly bundled</td>
<td>25</td>
<td>400.5</td>
</tr>
<tr>
<td>Billeted cane</td>
<td>22</td>
<td>352.4</td>
</tr>
<tr>
<td>Whole stick cane, tangled and loosely tipped into cane carrier</td>
<td>10</td>
<td>160.2</td>
</tr>
</tbody>
</table>

As previously stated, the move from manual harvesting of burnt cane to machine harvested green cane means a dramatic organisational change. Part of this change should be an overhaul of the cane transport system.

The system must be able to carry and unload billets, which have a much shorter allowable harvest to crush delay than whole stalk cane. New transport systems and transport scheduling arrangements are an integral part of the adoption of a machine harvesting system, particularly a system based on chopper harvesting.

Hand cut whole stalk or machine billeted cane will result in some increase in extraneous matter, typically trash and leaf, and a subsequent reduction in bulk density of the load. In some instances, a larger transport fleet may be required.

However, in many situations, sugarcane transport vehicles are mass-limited, i.e., load size is limited to prevent overloading of vehicle axles and tyres before maximum physical load dimensions are exceeded. This somewhat mitigates the effect of increasing trash on payload. In billeted cane, load density is affected both by billet length and by EM in the cane load. Frost and Stevenson (1980) demonstrated this effect, their results being used to derive Figure 2.

Further research on the impact of EM on load density was undertaken by Pope (1998). With machine harvested cane, he deduced that each percentage point of total EM reduced load weight by approximately 3%. Given the typical composition of EM in chopper harvested green cane that Pope was working with, this implies a reduction in load density of approximately 6% for each percentage point increase (weight basis) in trash and leaf.

![Fig. 2—Impact of billet length and EM levels on observed load density in chopper harvested cane.](image-url)
Other considerations

There are numerous other considerations that must be borne in mind when adopting a green cane harvesting regime. These include:

Cane quality

It has been shown in Colombia that, although manual cane cutter productivity was reduced in green cane (Table 4), there was an overall improvement in cane quality (pers. commun.\textsuperscript{4}). In South Africa, where the green cane is manually pre-trashed prior to manual harvesting and windrowing, cane quality trends were similar (pers. commun.\textsuperscript{5}).

Table 4—Manual burnt and green cane harvesting systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Output (t/man/day)</th>
<th>EM %</th>
<th>Cost (% of burnt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnt cane</td>
<td>6.0</td>
<td>2.53</td>
<td>100</td>
</tr>
<tr>
<td>Normal green cane</td>
<td>4.0</td>
<td>3.10</td>
<td>123</td>
</tr>
<tr>
<td>Clean green cane</td>
<td>2.5</td>
<td>0.78–1.00</td>
<td>130</td>
</tr>
</tbody>
</table>

Mechanically harvested cane reflects the composition of cane in the field, whereas handcutters will typically reject damaged and poor quality cane. Cane quality from any mechanised harvesting system must therefore be lower than hand harvested cane.

Chopped cane deteriorates more quickly than whole stalk cane (Irvine and Legendre, 1973; Eggleston et al., 2001). On a load-to-load basis, the level of extraneous matter can vary widely in chopper harvested cane, and depends on a number of factors including cane variety, yield, condition of crop, weather conditions and whether the crop was burnt before harvest or not.

Overall, there are not necessarily big differences in the levels of EM between chopper harvested cane which is burnt or unburnt. Table 5 presents data from the cane sampling system at Ramu Sugar in Papua New Guinea. The data represent approximately 4000 samples, taken hourly, from the 500 000 t cane supply in each of the nominated years. While extractor fan speeds were not changed when harvesting burnt or green crops, in 2003 there was a general attempt to reduce fan speeds to reduce all cane loss, and in line with normal operational strategies, pour rates in green cane were lower than in burnt cane.

Table 5—EM levels for 2002 and 2003 from cane sampling system (data courtesy of Ramu Sugar, Papua New Guinea).

<table>
<thead>
<tr>
<th>Cane description</th>
<th>Tops %</th>
<th>Leaf %</th>
<th>Loose soil %</th>
<th>Dead cane %</th>
<th>Non-sucrose EM. %</th>
<th>Side shoots %</th>
<th>Roots &amp; stalk %</th>
<th>Clean cane %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002 Green</td>
<td>3.5</td>
<td>5.1</td>
<td>1.4</td>
<td>0.9</td>
<td>10.9</td>
<td>1.0</td>
<td>1.2</td>
<td>86.9</td>
</tr>
<tr>
<td>2002 Burnt</td>
<td>3.8</td>
<td>3.0</td>
<td>1.3</td>
<td>0.8</td>
<td>8.8</td>
<td>0.9</td>
<td>1.3</td>
<td>89.0</td>
</tr>
<tr>
<td>2003 Green</td>
<td>5.1</td>
<td>5.9</td>
<td>1.3</td>
<td>0.58</td>
<td>12.9</td>
<td>0.8</td>
<td>1.4</td>
<td>85.0</td>
</tr>
<tr>
<td>2003 Burnt</td>
<td>5.2</td>
<td>5.6</td>
<td>1.2</td>
<td>0.51</td>
<td>12.6</td>
<td>1.2</td>
<td>1.7</td>
<td>84.5</td>
</tr>
</tbody>
</table>

Although the data indicate that the overall differences in cane harvested burnt or unburnt are small on a mass basis, on a volume basis the differences are more significant, as leaf material in burnt cane is primarily spines, versus the whole leaf in unburnt cane, the latter having very significantly more impact on load density.

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\textsuperscript{5} Mr D. Galvis, Manuelita Sugar Mill, Cauca Valley, Colombia
In Louisiana, numerous tests demonstrated that each 1% increase in extraneous matter caused an increase in fibre of 0.08–0.19%, a 1.25–1.40 increase in tonnes cane per hectare, and a 0.85–1.22 kg decrease in sugar per gross tonne of cane (Richard et al., 2001).

It is generally accepted that harvester manufacturers have made significant improvements to the gathering and feeding mechanisms and the cleaning systems of modern chopper harvesters. However, further improvements to overall machine performance, and gathering and cleaning processes need to be encouraged.

Alternatively, cane payment formulas could provide sufficient incentives for growers to utilise machine improvements to their full potential so that relatively clean cane is delivered to the factory. However, it must be borne in mind that there could be an increase in cane losses associated with harvesting cleaner cane, i.e. increased fan speed.

Given the obvious constraints on the performance of harvester cleaning systems, a strong argument can be made for additional secondary cleaning at the mill. Such an approach allows harvester operation to be optimised to minimise cane loss while ensuring that clean cane is supplied to the milling train.

In a holistic analysis, the increased transport costs associated with the mass of the trash and reductions in load density are small compared with the gains in mill performance, sugar quality and total sugar recovery. The major problems associated with cane cleaning at the mill are cane payment issues and disposal of the trash.

In the longer term, there is a dire need for plant breeders to develop cultivars specially adapted to both manual and mechanical green cane harvesting in each of the sugar producing areas. Some of the more important traits are high sugar content, robust, erect, non-brittle, loose leafed or free trashing, a trash to cane ratio below 30% and trash tolerance under a wide range of conditions (de Beer and Purchase, 1999).

**Trash management**

A move to a mechanical harvesting system, particularly chopper harvesting of unburnt cane, mitigates many of the trash-related handling problems. The cane residues are reduced in length and partially shredded, and are spread evenly over the field. This is excellent as a mulch, and also allows for easy row raking, either manually or mechanically if trash removal is required, or easy raking off the row if this is appropriate.

In Colombia, a forage harvester has been used successfully to chop the trash so that the necessary conventional cultural practices can be carried out (Cock and Torres, 1999). If a trash blanket is desired, trash has to be raked and spread.

Large quantities of trash can present significant problems, as evidenced in Colombia; however, even in countries with more moderate crop yields, e.g. the Philippines, trash is often burnt or removed after harvest to minimise agronomic problems.

A range of equipment exists which can be used to rake, spread and incorporate trash and tops into the inter-row, while other machines, such as a modified road brush, can be used to remove the trash from the top of the cane rows.

Where crop residues cause slow emergence or yield decline, this type of equipment provides growers with alternative management practices. Equipment to apply or incorporate plant nutrients on or under a trash blanket, is also well developed (Scandaliaris et al., 2005)

Much research work has been conducted around the world on the partial or complete removal of cane residue left on the ground after harvesting. In Brazil, around 60% of cane residue has been successfully collected, transported and fed to a factory’s boiler to generate electricity (Suleiman, 2001), with the remainder left in the field for agronomic reasons.

**Weed control**

A move to trash blanketing will, by nature, change the characteristics of the weed spectrum, and again, the impact of trash blanketing will change the way weed issues are dealt with. Under trash blanketing, there is little option for mechanical weed control. Selective herbicides or selective application become the primary weed control strategies.

Trash blanketing at Ramu Sugar in Papua New Guinea (PNG) was originally recognised as being highly effective in facilitating the control of Rotteboella cochinchinensis, an aggressive, exotic grass weed. Current Ramu experience is that the trash blanket saves at least US$0.25/t cane in weed control costs.
In Australia, trash blanketing has been shown to dramatically reduce weed control costs, with fields often requiring little active weed control. Work in Brazil showed that the weed control value of a trash blanket was approximately US$0.60/t cane (Ortiz, 2002). Creeping grasses such as Cynodon dactylon and vines can be a greater problem with trash blanketing under some conditions. The primary issue in achieving good weed control without smothering the ratoon crop is evenness of spread of the crop residues.

### Pests and diseases

The presence of trash can exacerbate pest problems. In South Africa, where stubble is left in the field after harvest, infestation of the stalk borer Eldana saccharina Walker (Lepidoptera: Pyralidae) will be higher in fields where trash is also present. Similarly, depressed early growth can make the impact of pests such as leaf eating caterpillars and armyworm more dramatic. In Tucumán, Argentina, Pseudaletia unipuncta (Haworth) (Lepidoptera: Noctuidae) was found to be the most important pest in green cane harvested fields (Scandaliaris, 2003).

In other environments, trash has been demonstrated to be highly beneficial in the control of pests. At the Ramu plantation in PNG, cicada damage can reduce the ratoon cycle length by more than half. The even trash blanket associated with machine harvesting has been demonstrated to be the most effective method available to combat this pest (Vaux et al., 2004).

The spread of diseases such as ratoon stunting disease, through the use of mechanical harvesters is a problem where appropriate levels of hygiene are not practised.

### Political, industrial and social considerations

Where labour-based sugarcane industries wish to move from burning to green cane harvesting, serious attention will have to be given to political, industrial and social considerations.

#### Political

If a green cane harvesting system is adopted by a predominantly manual harvesting sugar industry, it may be more economical to use a fully mechanical harvesting system due to poor hand cutter performance or high labour costs. Such a scenario lends itself to the possibility that regulations will be introduced to protect the labour market and force such an industry to use manual or semi-mechanised harvesting systems.

#### Industrial and economic

In an industrial context, there are several real risks associated with switching to a comprehensive green cane harvesting regime. Firstly, the cane delivered to the mills, although 'fresher', usually contains higher levels of EM, with an associated increase in total fibre. This factor is associated with reduced mill crushing rates and the likelihood of increased costs and a longer milling season.

Furthermore, industries operating a cane payment system based on cane quality may have to review their payment system. Secondly, the impact on pests and diseases will have to be considered, as well as the likelihood of accidental and natural fires.

Secondary cleaning systems at the mill deserve serious consideration in conjunction with any move into green cane harvesting. By operating harvesters to achieve moderate trash removal at low cane loss, and then removing the residual trash and other extraneous matter at the mill, overall cane loss can be minimised and the quality of the product being delivered to the mills will be maximised.

This approach has been successfully used in Cuba on a broad scale for many years. Both manual and mechanical harvesting would benefit from this option.

Economics will play a significant role in the decision whether or not to move to a green cane harvesting system. The transition from burnt to green cane harvesting is a lengthy process, as there are many difficulties to overcome and some of the benefits of trashing only become apparent with time.

As willing labour becomes more scarce and costly, some sugar industries will have to consider mechanised harvesting systems to assist them in remaining competitive on the global market. Identifying the most appropriate system will be influenced by the nature of the terrain and field conditions.

#### Social

It is postulated that if daily earnings were similar, in terms of a more pleasant working environment, manual cutters would prefer to harvest green cane despite the higher risk of self-inflicted injury, or illness through contact with vermin and toxins.
It is generally agreed that manual cutter performances are reduced when harvesting green cane. In industries where sugarcane is still harvested manually, the move to green cane harvesting will mean a significant increase in labour requirements. This poses several challenges regarding the availability and willingness of such labour, particularly in view of general trends towards urbanisation, minimum wages and improved levels of education. Nevertheless, any large-scale swing to mechanisation would be devastating to local communities that are directly or indirectly economically dependent on the sugar industry. In some developing countries, the impact of HIV-AIDS is likely to become a real threat to the use of hand cutters, especially those countries that wish to implement a green cane harvesting system.

Conclusions

It is recognised that, aside from the issues related to smoke and ash fallout, there are numerous advantages to green cane harvesting including improved cane yields, higher water infiltration rates, reduced water and soil run-off, slower cane deterioration and better weed control. Industries should therefore seek to take maximum advantage of these potential gains, which overshadow some of the negative issues associated with green cane harvesting.

Manual and mechanised green cane harvesting and transport systems have been developed and implemented successfully. Two important considerations that have contributed to this success are a comprehensive agronomic and economic study to assess the impacts of such a shift, and a thorough analysis of the current cost of operations. By carrying out similar studies, an industry will be able to clearly identify all the issues that will be affected by a change in practice, thereby allowing an accurate economic estimate of associated costs. A change to green cane harvesting will require more emphasis to be placed on developing both manual and machine friendly cane varieties for specific climatic and agronomic conditions.

Further research is required in developing trash-handling machinery to ensure that crop residues can be manipulated to suit varying climatic and agronomic conditions. There is also a need to develop best management practices for individual local conditions, to ensure economical and sustainable cropping systems. A green cane harvesting regime should not be seen as a threat but rather as a challenge to examine the potential advantages and opportunities associated with such a regime, such as alternative uses for cane residues.

Green cane harvesting presents the opportunity to develop new technologies and make significant advancements in productivity and profitability, while at the same time ensuring soil sustainability and protecting the environment.

REFERENCES


L’IMPACT DES SYSTEMES DE PRODUCTION DE CANNE POUR LA RECOLTE EN VERT SUR LES OPERATIONS AGRICOLES MANUELLES ET MECANISEES

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Résumé

BON NOMBRE d’industries de la canne à sucre à travers le monde ont déjà adopté – ou sont en passe de le faire – des systèmes de production de canne pour la récolte en vert. Certaines l’ont fait suite aux pressions exercées par les communautés locales ou en raison de la législation gouvernementale par rapport à la pollution de l’environnement. D’autres ont opté pour ce système pour diverses raisons d’ordre économique ou agronomique. Néanmoins, il est estimé que plus de 50% de la canne à sucre à travers le monde est encore aujourd’hui brûlée avant la récolte. Cette pratique est perçue comme une manière efficace de maintenir la performance élevée de la main-d’œuvre et des machines, tout en permettant d’envoyer une canne plus propre à l’usine. Cependant le brûlis est associé à bon nombre d’inconvénients dont la pollution de l’environnement et les pertes en sol et en eau. Par ailleurs, il a été reconnu que les délais entre la coupe de la canne brûlée et le broyage étaient une des causes principales d’une augmentation des taux de dextrane dans le sucre. Plusieurs facteurs doivent être considérés avant l’adoption d’un système de production de canne pour la récolte en vert, les aspects majeurs étant les changements nécessaires pour une adaptation à des régimes différents d’ordre agronomique et mécanique et par rapport à la main-d’œuvre. La performance de l’usine ainsi que les implications sociales et économiques ne doivent pas être négligées. Cette communication met en avant plusieurs de ces aspects qui doivent être évalués avant de passer d’un système à l’autre. Ces questions comprennent l’efficience et la performance des deux types de récolte, la manutention des résidus de la canne ainsi que la disponibilité et l’aptitude des équipements. D’autres aspects tels que la qualité de la canne, le chargement et le transport sont aussi discutés.
EL IMPACTO DE LOS SISTEMAS DE PRODUCCIÓN DE CAÑA EN VERDE EN LAS OPERACIONES AGRÍCOLAS MANUALES Y MECÁNICAS

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Resumen

MUCHAS industrias azucareras alrededor del mundo se han cambiado o están en proceso de cambiarse a los sistemas de producción de caña en verde. Algunas de estas industrias lo han hecho por las presiones de las comunidades locales o por las legislaciones gubernamentales relativas a la contaminación ambiental, mientras que otras lo han hecho por una gama de razones agronómicas y económicas. No obstante, se ha estimado que al momento más del 50% de toda la caña del mundo aún se quema antes de ser cosechada. La quema de la caña es vista como una manera efectiva de mantener altos rendimientos en las cosechas manual y mecanizada y de enviar caña limpia a los ingenios. Sin embargo, hay muchas desventajas asociadas con la quema, que incluyen la contaminación atmosférica así como pérdidas de suelo y agua. Atrasos desde el corte hasta la molienda en caña quemada han sido identificados como una de las causas principales del aumento de niveles de dextrana en el azúcar. Muchos factores deben ser considerados al pasar a un sistema de producción de caña en verde, con los aspectos principales involucrando a los cambios requeridos para adaptarse a diferentes regímenes agronómicos, mecánicos y de mano de obra. El rendimiento de las fábricas y las implicaciones económicas y sociales también deben ser tomadas en cuenta. Este documento señala muchos de los aspectos que afectan las consideraciones operacionales, económicas y sociales que deben ser evaluadas cuando se cambia de un sistema de cosecha con quema a uno en verde. Estos aspectos incluyen eficiencias y rendimientos de cosechas manuales y mecanizadas, manejo de residuos de caña de azúcar y disponibilidad y adaptabilidad de la maquinaria. Otras áreas tales como la calidad de la caña, alce y transporte de la caña de azúcar también son consideradas.